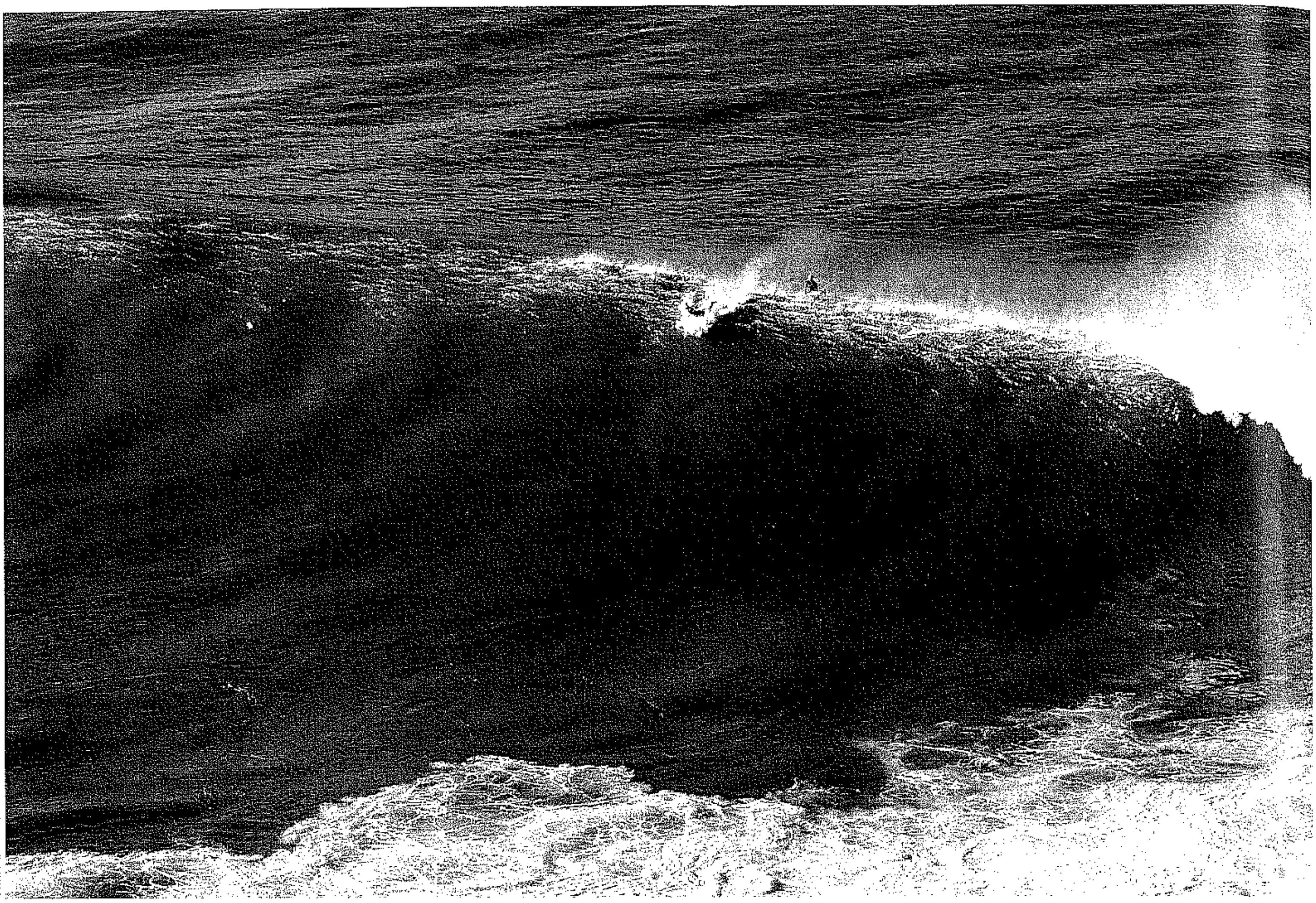


FERNANDO MUNOZ

WHY ARE BIG WAVES SO HARD TO CATCH?

By Tony Butt

Tony Butt completed a PhD in Physical Oceanography at the Centre for Marine Studies, University of Plymouth, England. He now lives and continues his research in Northern Spain.

Above - It ain't easy being a mouse to an oceanic elephant. Many factors conspire against us, not least our limited physical power. Doesn't stop us trying, though. Basque Country behemoth wins.

With the recent awareness that huge, rideable waves do exist outside the North Pacific Ocean, I thought it might be useful to have a look at a few points concerning how a surfer actually catches a wave and why big waves are so hard to catch.

Originally, this article was to be very brief. However, after several conversations with my compadres here in the Basque Country and various 'thought experiments', I realised that the art of catching a wave, expressed in scientific terms, is quite a bewildering affair, which merits more attention. Having said that, the following is still only a very brief overview, more for entertainment than serious application, since to explain all the details you would need to know about boundary layers, reference frames, Galilean transformations, and all the rest – it would be an impossible task. Further, however well you explain it scientifically, theory is one thing and practice is another. Plus, everybody knows you can't possibly "apply" any of these ideas when you're out in the water. What do all those strange symbols matter when a 20-footer is about to land on your head?

We start with the simple idea that, the bigger the wave, the faster you must go to catch it (hence today's use of wave-runners to tow into waves), then a brief explanation of the physics of how a wave is caught and the factors that put you either side of that fine line between glory and oblivion.

GO FAST AND GET IN EARLY

It is a well-known fact that the faster you get your board going, the earlier you get into a wave. Big waves travel faster than smaller waves, so to get in early on a big wave you must get your board going faster. This simple rule is illustrated in Figure 1. Here we can see that to catch the wave before its critical steepness (just before it breaks) you must have the board going at a certain speed. Too slow and either you won't catch it or you'll be over the falls. Some waves are so big and travel so fast that paddling is no longer enough – this is where some kind of mechanical aid is necessary.

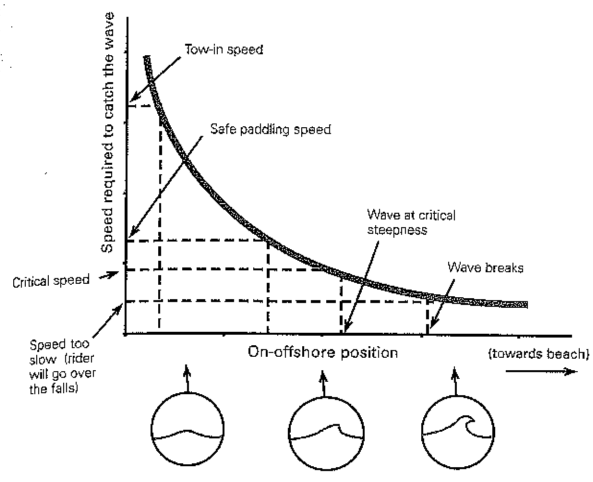


Figure 1: speed required to catch the wave plotted against on-offshore position (i.e. distance between some point offshore and the beach). If your speed and position are such that they coincide on the blue line, then you will catch the wave. The wave is propagating from left to right, so the further you are to the right of the graph, the steeper the wave and therefore the less fast you need to go to catch it. Too far to the right, however, and you are too late.

HOW FAST IS A WAVE?

Based on the above, it might be useful to have a look at how fast a wave is travelling just before it breaks. Table 1 shows the approximate speeds, just before the break point, for wave heights ranging from 1m (3ft) to 35m (100ft). I have included waves over 9m (30ft) although these are obviously 'not used' in normal surfing. These values were calculated using basic linear wave theory. It assumes (a) the speed of a wave in shallow water is proportional to the square-root of the water depth and (b) the wave breaks when the depth is about 1.3 times the height of the wave. It does not consider the changing shape of the wave profile due to the shoaling of the water or refraction. This would require using more complex theories, unnecessary for these basic comparisons.

Table 1: approximate speed just before breaking for waves of different heights.

Wave height (m)	1	2	3	6	9	18	35
Wave height (f)	3	6	10	20	30	60	100
Wave speed (km/h)	13	18	23	32	39	55	77

Looking at the top-end of the scale, we can see that, to match the speed of a 100-foot wave, the surfer would have to be propelled at 77kph (48 mph). Obviously, in huge waves, where paddling is out of the question, it is desirable to have enough speed to outrun the wave for safety purposes. I would suggest carefully reading the instruction manual of your new waverunner, even if you only want to go out in 30-foot waves.

Being able to catch the wave, although very closely linked with how fast you can propel the board, is not a simple case of matching the wave speed. For example, in the table we can see that a 2m (6ft) wave travels at about 18kph (11mph). Now a 2m wave is, by anybody's standards, easily catchable by paddling. But who can paddle at 18km per hour? Put another way, who can outrun a 2m wave by paddling?

This leads us to the suspicion that a wave can be caught by paddling much slower than the speed of the wave itself. How can this be?

HOW IS A WAVE CAUGHT?

In attempting to analyse, in simple terms, what happens when you catch a wave, I will be using an imaginary duck to illustrate wave dynamics.

The first thing we must realise is that, until a wave breaks, there is very little net displacement of water. An unbroken wave is not a moving mass of water, but a mobile bump in the water surface, the front face of which is a mobile slope. This slope will pass beneath any floating object (a duck, for example), lifting it up and eventually moving it in more or less a vertical circle. The assumption made here is that the duck is "fixed" on the water surface. Unless the wave breaks, even if it is very steep, it will not move the duck very far.

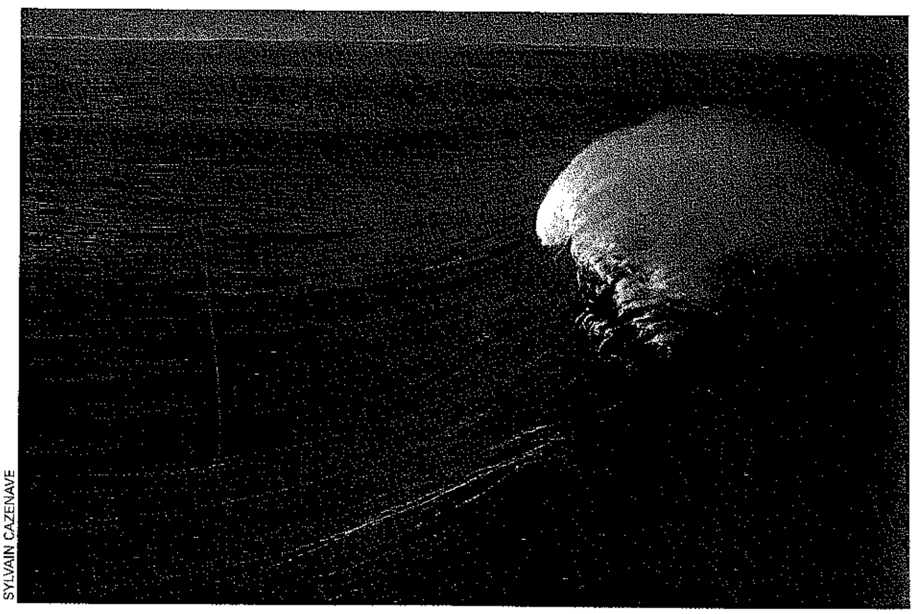
Now, imagine the duck on a frozen lake with waves on it (the ice is a special flexible kind). Suddenly, a wave comes up behind the duck. The wave tries to lift up the duck but it is so slippery that the duck immediately slides down the front face of the wave. The wave cannot 'get a grip' on the duck, so it just pushes it along. The duck has managed to catch this imaginary wave, and is surfing it, without having moved a muscle.

Next, imagine the duck on a lake with a rubber surface, also with waves. The duck sees a wave and tries to catch it, running as fast as he can. He runs as fast as the wave, first in front of it and then backs himself into the steep part of the wave. When he thinks he has caught it, he stops running. However, instead of sliding down the wave, he just stops dead and the wave passes underneath him.

These two 'thought experiments' show two ridiculous extremes, but also illustrate that a key factor in deciding whether or not a wave is caught is friction. In the first example, there is virtually no friction between the duck and the surface; that is why he catches the wave straight away. In the second example, there is so much friction that the duck will never catch the wave no matter how fast he runs in front of it. In real life, the friction between a surfer and the water surface is somewhere between these two limits.

Paddling for the wave must somehow reduce the effect of friction so that the surfer can begin to slide down the wave. One possible way of explaining how this happens is that there are three forces involved in catching a wave: friction (F), gravity (G), and your

Below -
Speed is what we need. If this is a 30' wave it's travelling at about 39kmh or 25mph. Doesn't sound like much, but try paddling that fast.



SYLVAIN CAZENAVE

paddling power (P). Friction is what tries to keep you stuck to the water surface, and gravity is what tries to get you sliding downwards. Your paddling arms exert a force in the same direction as gravity (strictly speaking, the component of gravity pointing down the wave). Figure 2 illustrates this balance of forces.

At first, the frictional force dominates. You are stuck to the surface and, if you do nothing, the wave will just pass underneath you. You start paddling and, at the same time, the wave steepens. Eventually, friction will be overcome by the other two forces, and you will begin to slide down the wave. Once the board has started sliding under the influence of gravity, it begins to lift out of the water, or starts to plane. This results in a rapid reduction of frictional drag. Therefore, you no longer need to add your paddling power to the force of gravity, as gravity alone is now sufficient to overcome friction. Paddling for the wave has literally kick-started the board, unsticking it from the face of the wave.

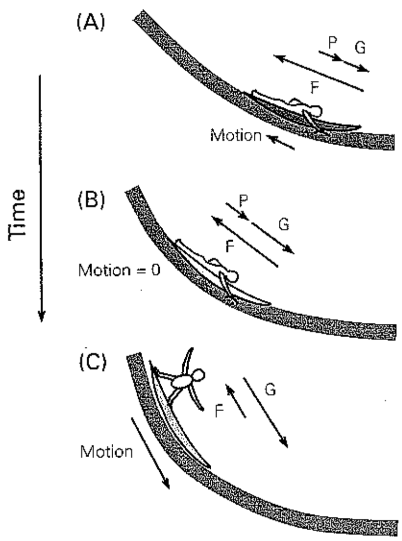


Figure 2: Balance of forces as a surfer catches a wave. In frame (a) the frictional force is greater than the sum of gravity and the paddling force of the surfer, therefore the resultant motion is backwards, up the wave. In frame (b) the forces are balanced, so the surfer is neither going up nor down the wave. In frame (c), the balance of forces is downwards; he has caught the wave, stopped paddling and has just got to his feet. The length of arrow is proportional to the strength of each force. The colour coding gives an added indication of the resultant motion.

WHY ARE BIG WAVES HARDER TO CATCH?

So, if all we need to do is overcome friction, why are big waves harder to catch? The answer does lie in the fact that big waves travel faster than smaller ones; however, it is a little more complicated than just the need to paddle faster because the wave is faster. In the scaled-up world of big waves, everything is happening more quickly and distances are much greater. We cannot risk being in the wrong spot at the wrong time. We want to be safe, get into the wave, and get to our feet before the thing steepens up too much. If we find ourselves stuck in the top quarter of the wave, we might become part of the lip and be hurled into oblivion.

So, in big waves, you have the double problem of having less time before the thing jacks up combined with the need to get in extra-early to avoid being launched. Therefore, force P in Figure 2 needs to be greater and/or F needs to start off smaller. This is why you need a bigger board that floats higher on the water surface (sticks to it less).

With tow-surfing, both of the above problems are immediately eliminated. The board is already at planing speed and into a lower frictional regime (it will readily slide down the wave without having to be unstuck), and the surfer is already on his feet, so the tricky take-off part is a non-issue.

The series of time 'snapshots' in Figures 3 and 4 show the difference between catching a small wave and catching a big one (by paddling). The paddling speed, which is increasing with time, is the same in both cases. In Figure 4, however, the wave is bigger and therefore approaching faster. In Figure 3, the surfer has plenty of time to get the board 'unstuck' before the wave steepens up too much – he can catch the wave, get to his feet, and drop down it safely. In Figure 4, on the other hand, he hasn't quite got enough time. Once he has finally caught the wave, it is too late – he's going over the falls.

Obviously, the time it takes to get from paddling the board to a good, solid stance becomes more critical the bigger the wave. In small waves, you can afford to take your time getting to your feet or if you don't get your footing quite right, chances are you'll still end up surfing the wave. In big waves, you not only have less time to get to your feet, since the wave steepens up so much more quickly, but you and the board are also accelerating rapidly down a wave face that may contain warps and chops, making a stable, low-centre-of-gravity stance vital.

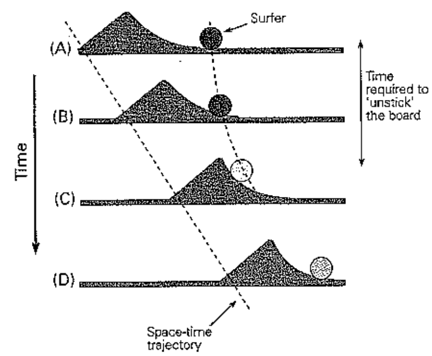


Figure 3: Time-series of 'snapshots' showing a surfer catching a relatively small wave. The wave and surfer each have their own space-time trajectory, whose angle is proportional to their speed. The surfer is catching the wave in frame (c). Colour coding as in Figure 2.

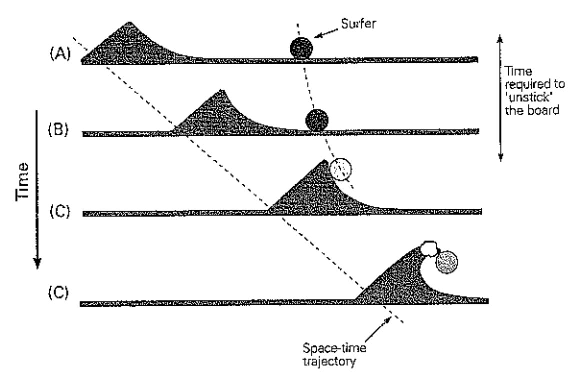


Figure 4: same as Figure 3 except this time the wave is bigger and is approaching faster, shown by the angle of the space-time trajectory. The surfer is paddling at the same rate as in Figure 3. In this case, he does not manage to catch the wave and get to his feet until the wave exceeds 'critical steepness'. Therefore he is over the falls.

THE WIND FACTOR IN BIG WAVES

One thing that becomes a very significant factor in big waves is wind. In small waves, offshore wind can be a delight; in big waves, it can be hell. In 'open-ocean' waves, the slightest offshore breeze is magnified to hurricane force as it is funnelled up the face, blinding you with spray and paralysing you in the top part of the wave until you are pitched like a human cannonball. Taking off requires a heavy board and plenty of weight on your front foot, which is counterintuitive. Once you feel that nose lifting, it's already too late. The late Jay Moriarty's horrible 1994 wipe-out says everything about offshore wind in big waves.

Moreover, if the line-up is a long way out, an offshore wind will build up a lot of chop, making those vertical drops even more perilous. Just to illustrate this, Table 2 shows how big the chops can get with offshore winds of various strengths for a line-up 1km from shore. The chop sizes were calculated by treating the chop in the same way as a normal swell, but with 'fetch-limited' conditions (the waves won't get any bigger for any given wind speed unless the line-up moves further offshore). Once the height of the chops exceeds the thickness of your board, things start to get difficult. From the table, we can see that, at a force 2, the chops are about 4cm high – actually quite big already, but probably not a problem. Turn the wind up to a force 6, however, and you're looking at 20cm chops, which would make take-offs extremely uncomfortable.

It is interesting that some beachbreaks can be surfed at huge sizes no matter how strong the offshore wind – often the stronger the better (bigger tubes and more chance of coming out). On the other hand, an open-ocean reef, picking up the same swell, on the same day, might be impossible to surf. One reason for this must be the difference in chop build-up between the two types of spot, with the open-ocean reef having a much larger body of water between the shore and the line-up. Two waves right next to each other in the Cape Peninsular area of South Africa are testament to this. One is a Puerto Escondido-type beachbreak where you can surf 3m (10ft) waves breaking practically on the shore in gale force offshore winds; the other, an outside reef where you wouldn't dream of surfing it at its minimum size of about 3m (10ft) in anything stronger than a force 3.

Table 2: up-the-face chop size as a function of various wind speeds, for a break 1km from shore.

Wind (km/h)	11	18	25	36	47	58	68
Beaufort scale (force)	2	3	4	5	6	7	8
Chop size (cm)	4	7	11	16	21	26	32

LANCE SLABBERT

Above - Offshores get magnified up the face and blow too hard so most big wave surfers prefer glassy conditions. Some swear by a very light onshore, but when it gets this big even a minor bump on the face becomes a mountain in itself.

Even with no wind, a really big wave will generate its own apparent 'offshore wind' as the air in front is pushed up the face (true for smaller waves too, but usually unnoticeable). To eliminate this self-generated wind, some surfers at Mavericks and Dungeons have suggested that a light onshore is better for surfing those huge waves. Personally, I don't think light onshores are a good idea. They cause the water surface to become choppy in just the same way as a strong offshore at an outer reef. This makes for double-ups and staircase take-offs. A nice, smooth, glassy surface is probably the best thing to hope for in big waves.

THEORY IS ONE THING, PRACTICE IS ANOTHER

Okay, that was just the theory. Anyone who has surfed big waves knows there's a lot more to it than funky little diagrams and schoolbook physics. Catching a wave without getting obliterated involves experience, knowing and respecting your surf spot inside-out, intuition and luck. You have to approach the situation with a kind of calm aggressiveness. Too 'gung-ho' and you'll just waste all your energy getting worked. Too hesitant and you'll end up frustrated.

Once the waves become so big that it is obvious that paddling is out of the question, then another set of parameters comes into play. The reliability of mechanical equipment and your ability to successfully work with it is what keeps you on the right side of that fine line.

Any comments or suggestions about this article would be most welcome: tony@swell-forecast.com